Effectiveness of cycled lighting in neonatal intensive care unit on weight and cardiorespiratory function in preterm infants

Salwa Ali Marzouk, Amal Abdrbou Hussien, Safwat Mohamed Abdel Aziz

Assistant Professor of pediatrics nursing, Faculty of Nursing, Assiut University, Assiut, Arab Republic of Egypt
Lecturer of pediatrics nursing, Faculty of Nursing, Assiut University, Assiut, Arab Republic of Egypt
Lecturer of pediatrics & neonatology, Faculty of Medicine, Assiut University, Assiut, Arab Republic of Egypt

Abstract

Hospitalization in neonatal intensive care units predisposes preterm neonates to negative stimuli such as continuous 24-hourlighting. Potential benefits and harms of different lighting in neonatal units have not been quantified. Therefore, this study aimed to evaluate the benefits of a cycled lighting (light/dark cycle) in the Neonatal Intensive Care Unit on weight and cardiorespiratory function in premature infants. A Randomized clinical trial performed on preterm neonates who hospitalized in NICU at Assiut University Children Hospital, Egypt. From admission to discharge, neonates were randomly exposed to cyclical lighting (study) or continuous lighting (control) groups, twenty in each one. A structured questionnaire was used to collect data and included personal data, weight and cardiorespiratory assessment. The Results of the study revealed that mean of neonates' weight in the study group was significantly greater than control group (P. 0.017). Mean pulse rates at 10 days and at discharge were significantly more stable in the study group compared to control group (p<0.002 & p<0.028). Moreover, the mean O_2 saturation is significantly better in study group than control (P<0.045).

Conclusions: Cycled lighting is an effective strategy to improve premature neonates' weight and cardiorespiratory function.

Recommendations: Nurses should be aware of the importance of applying the Cycled lighting at NICU to improve preterm neonates' health.

Keywords: Cycled lighting, weight, cardiorespiratory function, and preterm infants

Introduction

During the last two decades, the number of preterm neonates has increased mainly due to an increase in the number of preterm deliveries. Around 310 million neonates are born annually in the world, while 15% of them are premature (W.H.O., 2017) [22]. Premature neonates need life support services and hence are hospitalized in Neonatal Intensive Care Unit (NICU) (Klock and Erdmann 2012) [8]. Evidence reports high rates of prolonged hospitalization in developing countries (Martin, *et al*., 2014) [11] with a mean NICU stay of as high as 33 days (Alizadeh, *et al*., 2013) [1].

Although neonatal intensive care units provide highly specialized medical care, they do not necessarily offer an ideal environment for the development of newborn infants. The physical environment (light, temperature, sound, radiations) in the NICU is a critical issue, which can affect the normal development of a newborn infant (Hunt, 2011) [6].

There is a huge difference between intrauterine environment and the NICU environment. The pregnant woman is exposed to variable intensities of light and sound, and generally to lower levels at night. Some of the light and sound reaches the fetus within the womb and induces circadian rhythms. 'Circadian' is a term used to describe biological processes that recur naturally on a 24-hour basis. After birth, preterm infants are cared for in an environment that has no planned light-dark cycles and no other circadian entraining signals (Morag and Ohlsson 2016) [14].

One of the main concerns about neonates, who are hospitalized in the NICUs, is their early exposure to intense and unpredictable lighting. In these units, neonates are almost constantly exposed to continuous lighting which have been associated with adverse clinical outcomes: less weight gain, behavioral and sleep disturbances, in addition to stress in preterm. (Peng, *et al*., 2009) [17]. Using artificial entraining signals in the nursery, that is, CL may prevent these disturbances and may help to promote growth while preventing other morbidities.

CL has the potential to promote circadian rhythms that confer health benefits, including hormonal regulation, activity-rest cycles and vital sign regulation, with the potential of promoting infant growth (Verklan and Walden, 2014) [21]. Therefore, a controlled intervention (cycled lighting) may have systematically favored physiological stability and reduced motor activity level in the studies with a continuous bright light comparison group. In contrast, continuous light or dark conditions delay the onset of circadian behavioral rhythms and lead to reduced weight gain in preterm infants (Morag and Ohlsson 2016) [14].

Compared to other healthcare professionals, nurses are more actively involved in providing care to neonates. Therefore, nurses should control lighting in the NICU to promote the environmental adaptation of preterm infants and avoid unsuitable responses indicative of stress. In this way, one of the strategies, which can be aimed at lighting control, is to create artificial day and night. This strategy is noninvasive, incurs no cost, and can be used as a basis for organizing the delivery of other care services.

Significant of the study

Previous studies with significant improvement in physiological stability and motor activity levels in premature infants compared a controlled lighting intervention to continuous bright light, which is known to berelated to physiological instability and increased motor activity level in premature infants (Rivkees, *et al.*, 2004) [19].One study also, comparing the effects of continuous and cyclical lightings among preterm neonates indicated that effectiveness of cyclical lightings in improving weight gain and shortening hospital stay (Esmaeilizadeh, *et al.*, 2016) [3].While a clinical study showed that cycled lighting had no significant effects on weight gain (Guyer, *et al.*, 2012) [5]. Due to the contradictory results of previous studies, this study conduct to confirm the best way of lighting in NICUs.

Aim of this study

The study aimed to evaluate the benefits of a cycled lighting in the NICU (light/dark cycle) on weight and cardiorespiratory function in premature infants.
This was done through the following:

1. Evaluate the effect of cycled lighting versus continuous light on weight in preterm infants.
2. Investigate the effect of the intervention (cycled lighting) on cardiorespiratory function in premature infants.
3. 3- Assess the effect of the intervention (cycled lighting)on hospital stay in premature infants.

The hypothesis of the study

H1- Infants with cycled light have greater weight than those who exposed to continuous light.
H2- Infants with cycled light possible have better cardiorespiratory function than those who exposed to continuous light.
H3- Duration of hospital stay in cycled lighting group is shorter than continuous light group.

Subjects and methodsResearch Design

Randomized clinical trial was used in this study.

Setting

This study was conducted in Neonatal Intensive Care Unit(NICU) at Assiut University Children Hospital.

Sample

Sample size was calculated based on previous studies (the Lee and Bang (2011) [10] study for which physiological stability was evaluated and a group size of 16 subjects per group was calculated for a total sample of 32. Also, the experimental study by Rivkees *et al*. (2004) [19] which explored cycled lighting, the size of the sample was 38 participants (19 per group). A purposive sample of 40 neonates (both sex) admitted to NICU included in the study.They assigned to two groups; cycled lighting (study group) or continuous light (control group). Neonates selected basedon the inclusion and exclusion criteria.

Inclusion criteria: Included infants were ≥32 weeks of gestational age (according maternal last menstrual period, orthe Ballard scores), delivering by vaginal or cesarean section delivery, hospitalized in the NICU for at least for 10 days.

Exclusion criteria: Included; Neonates with congenital anomalies, who requiring a long period (more than 12 h) of continuous lighting for frequent treatment interventions, were receiving medications like catecholamine that could influence cardiorespiratory function stability, had obtained an Apgar score less than 6 at 5 minutes of life or who died before discharge.

Tools

A structured questionnaire was used to collect data pertinentto the study and included the following parts.

Part one): Personal Data: It included sex, gestational age, age on admission, date of admission, date of discharge,diagnosis and mode of delivery. The data for this part was extracted from infants' medical records. Length of hospital stay was calculate as the time from admission until day of discharge home.

Part Two: weight gain assessment
Studied infants were weighed each morning, using a digital weighing scale (SECA, Germany) by the nursing staff in charge of each infant. The infants' weight on admission (as baseline), on 10th day and on discharge documented in a standard format. All infants in both groups weighed naked.

Part Three: Assessment of cardiorespiratory function to evaluate heart rate, respiratory rate, and O2 saturation levels. Observation for the 3 parameters over the 24-hour, daytime, and nighttime periods were done. The Coefficient of Variation (CV) (standard deviation divided by the mean) and the means were also calculated for each of them. The CV indicates the variability of the physiological parameter. This makes it possible to identify a physiological parameter that varies considerably, but whose mean is situated within the normal range.

Reliability and validity of the tools

Tools submitted to a panel of three experts in the field of Pediatric Nursing and Medicine to test the content validity. No Modifications were carried out according to the panel

judgment on the clarity of the sentences and appropriateness of the content. The content validity was 94%. Reliability analysis was conducted to investigate the instrument internalconsistency, which used in the study; Cronbach alpha coefficients was calculated to examine the measurement reliability with multipoint items and its result was R=0.77.

Operational definitions

- **Cycled Light (CL):** is define as lighting that follows a day–night cycle to promote the establishment of a circadian rhythm in preterm infants.

Pilot study

A total 10% of the sample (4) were included in the pilot study in order to assess the feasibility and clarity of the tool. Neonates included in the pilot study excluded from the study sample.

Field of the work

Assessment phase: In this phase, data was collected to cover a period of 6 months from the beginning of May 2017 to end of October 2017 in the Neonatal Intensive Care Unit at Assiut University Children Hospital.

Implementation phase: In this phase, the selected neonateswere assigned into two groups (20 for each). At the begaining, researchers provided all nurses instructions aboutthe study intervention in three separate sessions (the morning, evening, and night shift). The first selected group was the control group. No protocol or single definition is available for time cycles or for maximal and minimal lux lighting used for cycled lighting, which usually provided ina 12-hours day/12-hours night pattern, similar to changes in natural light. A time of transition between day and night occurs at the change of nursing shifts (7 am and 7 pm). Bright fluorescent strip lights that remained permanently

lighted on the control group. During the daytime, the environment was identical in the two groups. At nighttime (7 pm) in the study group infants, the cycled lighting intervention achieved by placing dark pads over the infant's eyes and then maintained until 7 am. The intervention continued at least for 10 days or up to discharge. The nurses of the study setting implemented cycled lighting.

To ensure that all staff were compliant with the types of lighting regimen assigned to the infants, twice a day, one of the researchers checked that the lighting protocol for each infant was adhered to.

Evaluation phase

For both groups, weight and cardiorespiratory function evaluated on admission, after 10 days and on discharge.

Ethical Considerations

An official permission was taken from the authoritative personal in the hospital. The researchers introduced themselves to the neonate's parent whom their baby met the inclusion criteria and informed them about the aim of the current study and written assent obtained from them. Confidentiality and anonymity of them assured through coding the data.

Statistical analysis

Data was coded and transformed into a specially designed format suitable for computer feeding. All entered data verified for any errors. Data were analyzed using statistical package for social sciences (SPSS) version 20 windows and presented in tables and graphs. Frequencies analysis performed and Chi-square test were used in comparisonbetween two related groups having qualitative data. In addition, repeated measures Fisher Exact test, Mann-Whitney test, mean and standard deviations were computed. An alpha level of 0.05 was used to assess significant differences.

Results

Table 1: Personal characteristics distribution of the studied infants in two groups.

Item	Study (n= 20)	Control (n= 20)	P-value
Sex:			
Male	14 (70.0%)	17 (85.0%)	0.451
Female	6 (30.0%)	3 (15.0%)	
Mode of delivery:			
Cesarean Section	15 (75.0%)	14 (70.0%)	0.723
Normal Vaginal Delivery	5 (25.0%)	6 (30.0%)	
Gestational age: (weeks)			
Mean ± SD	33.70 ± 1.45	33.60 ± 1.54	0.780
Range	32.0 – 36.0	32.0 – 36.0	

The study sample included 40 neonates admitted in Neonatal Intensive Care Unit (NICU) at Assiut University Children Hospital. Table (1) denotes personal characteristicsof the studied neonates in the study (infants exposed tocycled lighting) and control (infants exposed to continuous lighting) groups. The mean gestational age on admission of the two groups was thirty-three weeks. The majority of the study and control groups were male (70.0% and 85.0%,respectively). Furthermore, there was a similarity between the two groups regarding mode of delivery mission.

Table 2: Mean and Median duration of feeding routes among the studied infants at both groups.

	Study (n= 20)	Control (n= 20)	P-value
Gavage feeding:			
Mean ± SD	2.25 ± 0.50	5.83 ± 5.88	0.001*
Median (Range)	2.0 (2.0-3.0)	2.5 (2.0-16.0)	
Oral feeding:			
Men ± SD	19.62 ± 12.29	9.71 ± 9.51	0.050*
Median (Range)	23.5 (1.0-35.0)	7.0 (1.0-30.0)	

able (2) illustrates that the mean duration of gavage feeding and oral feeding for the study and control groups was (2.25 & 19.62) and (5.83 & 9.71) respectively. Added to that, there was a statistically significant difference between the study and the control group regarding the duration of gavage feeding and oral feeding (p=0.001& p=0.050, respectively). This is evident that cycled lighting might enhancement oral feeding.

Table 3: Changes of mean infants' weight in both groups throughout intervention phases (at admission, 10 days and at discharge).

Weight	Study (n= 20)	Control (n= 20)	P-value
Weight at admission			
Mean ± SD	2.00 ± 0.46	2.05 ± 0.78	0.447
Range	1.5-3.0	1.5-4.1	
At 10th day:			
Mean ± SD	2.45 ± 0.48	2.19 ± 0.78	0.017*
Range	1.7-3.6	1.5-4.3	
At discharge:			
Mean ± SD	2.56 ± 0.47	2.33 ± 0.80	0.058
Range	1.7-3.6	1.3-4.4	

Mann-Whitney test

Table (3): shows the effect of intervention protocol on studied infants' weight throughout specific time parameters (on admission, 10 days and on discharge). There was similarity of mean infants' weight on admission between thestudy (cycled lighting) and (continuous lighting) control groups (2.00 ± 0.46 &2.05 ± 0.78, respectively). After 10 days with the intervention, the infants in study group showed a significantly greater weight gain than those in control (P. 0.017). On discharge, there was no statistically significant difference between two groups. In spite of this, the mean infants' weight in study group was still higher thanthe control group (2.56 ± 0.47 & 2.33 ± 0.80, respectively)
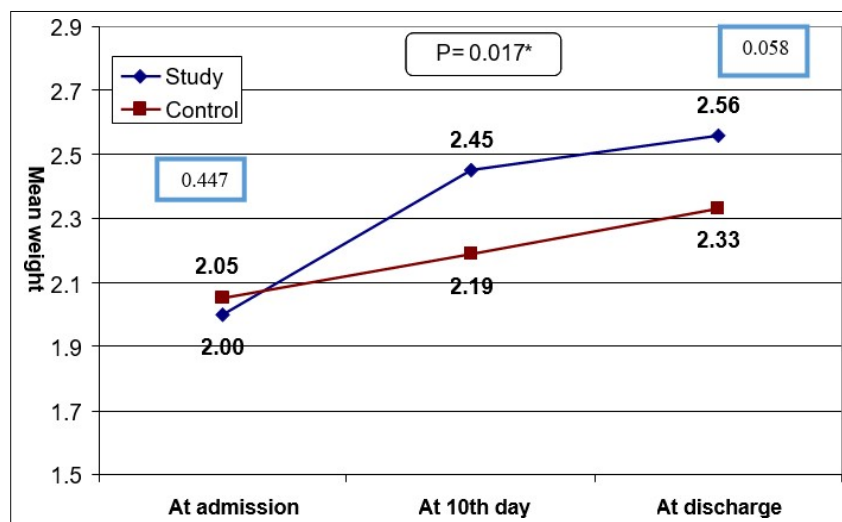
Fig 1: Mean weights' changes of infants in the study and control group throughout intervention phases (at admission, 10 days and at discharge).

Table 4: Comparison mean infants' cardiorespiratory function between the two groups throughout intervention phases (at admission, at 10 days and at discharge)

		Study (n= 20) Mean ± SD	Control (n= 20) Mean ± SD	P-value
Pulse	At admission:			
	Mean ± SD	133.25 ± 21.35	136.65 ± 10.16	0.375
	Range	95.0-188.0	120.0-152.0	
	At 10th day:			
	Mean ± SD	132.15 ± 13.54	143.25 ± 8.04	0.002*
	Range	92.0-144.0	130.0-158.0	
	At discharge:			
	Mean ± SD	132.95 ± 10.91	139.45 ± 6.97	0.028*
	Range	100.0-142.0	128.0-151.0	
Respiration	At admission:			
	Mean ± SD	58.35 ± 16.33	54.50 ± 14.17	0.506
	Range	34.0-82.0	40.0-86.0	
	At 10th day:			
	Mean ± SD	49.05 ± 15.14	46.80 ± 8.31	0.751
	Range	32.0-92.0	30.0-65.0	
	At discharge:			
	Mean ± SD	45.80 ± 11.30	45.30 ± 4.97	0.164
	Range	38.0-78.0	35.0-54.0	
O_2 saturation	At admission:			
	Mean ± SD	90.50 ± 5.75	91.10 ± 6.16	0.674
	Range	80.0-99.0	78.0-99.0	
	At 10th day:			
	Mean ± SD	95.00 ± 2.55	95.67 ± 2.50	0.676
	Range	90.0-98.0	93.0-99.0	
	At discharge:			
	Mean ± SD	98.65 ± 0.49	98.25 ± 0.79	0.045*
	Range	98.0-99.0	97.0-100.0	

Table (4) compares the pulse, respiration, and O_2 saturation for the study (cycled lighting) and control group (continuouslighting) throughout three point of time. At admission, there is no significant differences between the two groups regarding studied three parameters of cardiorespiratory function. Regarding pulse parameter, pulse improvement were revealed in both groups and mean pulse rates at 10 days and at discharge were more stable in the study group (132.15 and 132.95, respectively) compared to control group (143.25and 139.45, respectively) with statistically significant differences (p<0.002 & p<0.028). This revealed that cycled lighting might have effect on infants' pulse stability and improvement. While, there were no statisticallysignificant differences between two groups for the mean respiration at 10th day and at discharge (P= 0.751 & P= 0.164, respectively). The comparison of two groups using the mean calculated for O_2 saturation levels revealed that there was no significant difference between them at 10 days (P= 0.676) but later on discharge the mean O_2 saturation for the study group significantly good compared to the control group (P = 0.045). This positive finding may also be related to the fact that the light control intervention occurred over longer periods.

Table 5: Duration of hospital stay (days)

Hospital stay (days)	Study (n= 20)	Control (n= 20)	P-value
Mean ± SD	16.55 ± 7.71	20.15 ± 8.95	0.110
Median (Range)	14.5 (9.0-34.0)	18.0 (10.0-38.0)	

Regard to the comparison between both groups regarding duration of hospitalization in NICU, table (5) shows infants in the study group spent 9 to 43 (mean 16.5) days before discharge compared to 10 to 38 (mean 20.1) in the control group, with no statistically significant difference (P= 0.11).

Discussion

The findings of the current study covered three main areas discussed within the following frame of references: First, characteristics of the studied participants. Second, the effect of cycled lighting on infants' weight, cardiorespiratory function and on the duration of hospitalization. Regarding characteristics of the studied infants in in the study (infants exposed to cycled lighting) and control (infants exposed to continuous lighting) groups, results of the current study specified that there were similarities between the two groupsregarding sex, mode of delivery and mean of gestational ageon admission. Furthermore, there was no significant difference between the two groups regarding weight on admission. In the same line Farahani *et al*., (2018) [4] who compare the effects of cycled lighting (CL) and constant lighting on weight gain and the length of stay in NICU among premature neonates. They mentioned that there were no statistically significant differences between two groups regards neonates' route of delivery, gestational age and reason for hospitalization. In addition, Lebel, *et al*., (2017) [9] noticed that there was no significant difference between characteristics of the preterm infants randomized to the cycled lighting group and those randomized to the continuous near darkness group with regard to gestational age, weight at admission, type of delivery and respiratory support.

As regards, the effects of CL and constant lighting on studied infants' weight from admission at NICU until discharge. The mean of weight in the study group was not significantly different from the control group at admission. At the 10th day, neonates in both groups started to gain weight. This weight gain can be attributed to the fact that almost all neonates physiologically lose 10%–15% of their birth weight in the 1st week after birth and then start to gain weight in the 2nd week. (Noel-Weiss, *et al*., 2008) [16]. The mean of weight at 10th day in the study group was significantly greater than the control group. In addition, at discharge weight gain is still higher in the study group than control but without significant differences. Of course, the higher weight in the study group can be due to the positive effects of CL. An explanation for this difference between two groups comes from the results of the current study, which evidenced that cycled lighting might enhancement oral feeding. Add to that, Morag and Ohlsson, (2011) [15] supported this and mentioned that artificial cyclical lighting could enhance the quality of nutrition, growth and reduce mortality rate among preterm neonates. Moreover, the fact that the establishment of circadian rest-activity patterns and postnatal weight gains among preterm infants is accelerated in Neonatal Intensive Care Units that employ regular light- dark cycles (Ikeda, *et al*., 2015) [7].

In harmony with the present findings, the two-group randomized controlled trial by Vásquez-Ruiz *et al*., (2014) [20] was designed comparing infants in the NICU of HospitalJuarez de México, exposed from birth either to a light/dark (LD) environment (*n* = 19) or to the traditional continuous light (*n* = 19). Light/dark cycle intervention was achievedby placing individual removable helmets over the infant's heads. Body weight gain was analyzed, as the main indicator of stability and the main criteria for discharge. Results showed that infants maintained in an LD cycle gained weight faster than infants in traditional continuous light did (*P* > 0.01). Similarly, Esmaeilizadeh, *et al*., (2016) [3] did a research to test the effects of light exposure on weight gain among preterm neonates hospitalized at the NICU Bojnord, Iran. They recruited 60 preterm neonates. The neonates in the first group were exposed to continuous light while in the second group; the neonates were placed in an environment with cyclical lighting until the time of their hospital discharge. They reported that neonates with the simulated cyclical lighting model had greater weight gain. Moreover, cyclical lighting can increase the production of growth related factors, facilitate weight gain and improve health status among neonates. All of the previously mentioned studies assured the importance and good effect ofcycled lighting.

A more recent study done by Farahani *et al*., (2018) [4] who compare the effects of CL and constant lighting on weight gain among premature neonates. In their study CL consisted of 12 h of normal NICU lighting and 12 h of reduced lighting by using a sheet of acrylic glass (commerciallyknown as plexiglass) covered by a dimming cotton cover. The results found that there was no significantly difference between two groups respecting neonates' weight in the first 8th days (P = 0.857). While weight mean in days 9–15 inthe intervention group was significantly greater than thecontrol group (P < 0.001). Therefore, the relatively old and recent researches supported the current study findings and confirmed the importance of the application of Cyclical lighting,

meaning natural day/night-based lighting on facilitate weight gain.

The results of other studies in this area are in contrary to the current study findings. For instance, A quasi-experimental study was performed on 38 preterm neonates, who were randomly allocated to cyclical lighting (experimental) orcontinuous lighting (control) groups for five days had no significant difference between the groups neither before nor after the study intervention regarding the pattern of weight gain (Reyhani and Sanadgol, 2016) [18]. An explanation for this contradiction is the fact that day-night synchronized cyclical lighting does not significantly affect neonates' weight gain during the first days of the intervention (Rivkees *et al*., 2004) [19].

Another study also was carried out on preterm infantsadmitted to a neonatal intensive care unit. The aim was tocompare the weight gain between preterm infants exposedto 12h cyclical lighting (CL) and those exposed to acontinuously dim environment (both started in hospital andcontinued after hospital discharge). It showed no significantdifference between the effects of CL and dim lighting onweight gain of premature infants (Mirmiran, *et al*., 2003) [12].This is contrary to present study findings may be due to thedifferences in lighting intensity. In current study, neonatesof the control group were exposed to continuous lightingwhile neonates in their control group placed with dimlighting. Seemingly, dim lighting is less stressful forneonates than continuous lighting, resulting in insignificantdifference between the groups in Mirmiran, *et al*., [12] study. The effect of CL on studied parameters of cardiorespiratoryfunction has been explored in the present study. Regarding pulse parameter, the findings point to cycled lighting mighthave effect on infants' pulse stability and improvement. Addto that, the comparison of two groups regarding O_2saturation levels revealed that there was no significantdifference between them at 10th day but later on dischargethe mean O_2 saturation for the study group significantlygood compared to the control group. Therefore, a controlledintervention (cycled lighting) may have systematically favored physiological stability with a continuous bright lightcomparison group. In line with these findings, a study proved that CL caused significant positive physiological changes compared with constant lighting and found CL effective in promoting heart rate stability (Reyhani and Sanadgol 2016) [18]. Too, A randomized study with intervention exposure time from birth until hospital discharge observed improvement in oxygen saturation and in the rhythmicity of the heart rate in infants exposed to cycled lighting over continuous bright light (Vásquez-Ruiz, *et al*., 2014) [20]. In addition, Morag and Ohlsson (2013) [13] stated that bright light to be associated with a significantly greater amount of active rapid eye movement (REM) sleep, which was regarded as a relatively destabilized state with fluctuations in heart rate, blood pressure and oxygen saturation.

In contrast, Lebel, *et al*., (2017) [9] study found no statistically significant differences in physiological stability in preterm infants born between 28 and 32 weeks when exposed to cycle lighting and continuous near darkness. In addition, infants were physiologically stable throughout the study in both intervention groups. This discrepancy might be attributed to the differences in neonates' gestational age and the cycled protocols used in these two studies. Another explanation for the lack of differences in their study that these light-controlled interventions (cycled lighting and continuous near darkness) are safe for physiologic stability of premature infants.

The present study findings revealed that the study groupsdid not differ significantly from each other regarding infants' NICU stay duration. Similarly, a recent study compared the effects of cycled lighting (CL) and constant lighting on the length of stay in NICU among premature neonates found that no significant difference was observed between the two groups (Farahani, *et al*., 2018) [4]. While a study illustrated that significantly short hospital stay among the neonates treated with the simulated cyclical lighting model compared with the neonates who were exposed to continuous lighting (Esmaeilizadeh, *et al*., (2016) [3]. A probable explanation for such contrary findings may be the differences in the gestational ages and intervention protocol used of these two studies. Besides, the length of neonates' stay in the hospital is a good indicator for assessing the quality of health-care services (Atienza, *et al*., 2008) [2].

Finally, this study has several important findings that can beconsidered as a basis for more comprehensive studies on theeffects of cyclical lighting on preterm neonates in the Upper Egypt. As with any research, there are certain limitations of the study firstly, the sample size was relatively small, but it is comparable to previous studies that measured the impact of lighting control on preterm infants. Secondly, the study setting was a single NICU. Therefore, the findings should interpreted and generalized with caution.

Conclusion

The study concluded that implementation of cycled lighting protocol led to statistically significant improvements in the pattern of weight gain, pulse stability and O2 saturation in the preterm neonates. Investigators have observed the motivating conclusion during the study that there was no significant difference in the mean of hospital stay between preterm infants exposed to cyclic lighting and those exposedto continuous light.

Recommendations

On the light of the study findings, it is recommended that:

- Nurses in NICU can use the findings to improve neonatal outcomes among premature neonates hospitalized in NICUs.
- Future multicenter researches needed to provide strong evidence respecting the effects of CL on preterm health and development.
- Further researches are still needed to examine effects ofCL on both physiologic and circadian rhythm outcomes.

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